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Perspectives of Science and Technology in Disaster Risk Reduction of Asia

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Abstract Science and technology innovation has always been present in Asia, but its application in disaster risk reduction (DRR) has been differential. In Asia, globally significant hotspots of disasters and economic development have emerged in which the application of science and technology in DRR has become an essential requirement for informed decision making. Science has supported establishment and implementation of major international initiatives in DRR, including the Hyogo Framework for Action 2005–2015. The more recent Sendai Framework for DRR 2015–2030 recognizes the importance of science and technology in all of its priority action areas, and subsequent global and regional forums and conferences have reconfirmed science and technology's importance. To perceive and monitor the progress of science and technology in DRR, a qualitative assessment of different countries is made using three major attributes: (1) science-based decision making; (2) investment in science and technology; and (3) the intensity of science's link to the public. This assessment exercise points out several strengths and weaknesses in science and technology application; the method can be employed to develop future multistakeholder and multidisciplinary science and technology plans at the country level. To implement regional and national activities, a set of 15 recommendations is put forward, which will strengthen the collective regional "science voice" in DRR.

Keywords DRR policy making · Science innovation · Science investment · Sendai Framework · Technology application

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1 Introduction

Science and technology for disaster risk reduction (DRR) has always existed in some form in all countries. Through scientific research progress, disaster risk reduction has benefitted, especially in terms of early warning systems (EWS) that identify risk at various spatial and temporal scales and construction techniques that strengthen the resilience of buildings and infrastructures to different types of hazards, among many other examples. There have also been significant achievements in recognizing the role of higher education in disaster risk reduction, both as a specialized subject and by the integration of disaster studies into a broader higher education curriculum. In recent years, in addition to contributions from "hard" science or natural science, the importance of "soft" or social sciences have also gained prominence. A positive outcome attained from the analysis of many different major disasters has been the realization that there needs to be a good balance between the hard and soft technology, and engineering and social solutions.

Over at least last three decades, Asia has been a disaster hotspot, as well as hotspot of economic development and the development of science and technology. Soon after the adoption of the Hyogo Framework for Action 2005–2015 (HFA), a collective consensus emerged that strategies for

DRR require a more integrated approach, one that engages all scientists, engineers, and policy planners. Based on this more integrated policy perspective, policy guidelines in the post-HFA period should be better able to integrate science and technology. Several science-policy negotiations and multilateral dialogues contributed to the post-2015 framework for DRR, which identified the need to bring science and technology into the policy and planning mainstream in order to achieve more effective risk reduction (Chatterjee et al. 2015).

This article analyzes in global perspective the application of science and technology to DRR, as the background to an examination of the Sendai Framework incorporation of science and technology developments. This traces the Asian evolution of science and technology in pre- and post-Sendai timeframes. One of the key aspects of the article is the analysis of science and technology attributes in disaster risk reduction in 11 Asian countries. These observations are used to develop recommendations intended to enhance the future role of science and technology in DRR in the region. The most valuable contribution of this article lies in two contexts: (1) its historical review of science and technology evolution pre- and post Sendai with a specific focus on Asia; and (2) a qualitative analysis of the status of science and technology in Asia and their influence on policy processes at regional and national levels. Therefore, the article is not a pure academic exercise, but rather derives its importance from its contribution to the development of an integrated global, regional, and national policy regime that promotes disaster risk reduction.

2 Science and Technology Application in DRR: Global Perspectives

The relation of science and technology in a formal way as an intergovernmental issue dates back in the 1980s, when Frank Press, then President of the International Association of Earthquake Engineering (IAEE) conceptualized and made creditable the idea of an international decade of disaster reduction. The basic motivation behind the proclamation of the International Decade for Natural Disaster Reduction (IDNDR) (1990–1999) was, and still remains, the unacceptable and rising levels of material and mortality losses that disasters continue to inflict when there exists a wealth of scientific and engineering know-how that could be effectively used to reduce disaster impacts. The 1987 UN General Assembly Declaration:

> calls upon all Governments to participate during the decade for concerted international action for the reduction of natural disasters and, as appropriate, to establish national committees, in co-operation with the relevant scientific and technological communities, with a view to surveying available mechanisms and facilities for the reduction of natural hazards, assessing the particular requirements of their respective countries or regions in order to add to, improve or update existing mechanisms and facilities and develop a strategy to attain the desired goals (UN 1987, §7).

During the IDNDR, a Science and Technical Advisors (STA) group was formed to support the application of scientific knowledge and technology for disaster prevention, preparedness and mitigation, including the transfer of experience and greater access to relevant data (STAG 2015). In the concluding year of the IDNDR, the Geneva Program Forum has identified the progress of Science and Technology research as:

> substantial progress has been achieved in understanding the cause and effects of natural hazards. Nevertheless, further efforts are needed, especially with respect to risk assessment and warnings. Multidisciplinary efforts are needed for many problems, especially to better integrate physical and social sciences (UN 1999, §77).

The IDNDR was able to enhance national and local government awareness of disaster issues, highlight the need for pre-disaster preparedness, and emphasize the roles of different stakeholders, including the science, technology, and academia sector.

Following the establishment of UNISDR (United Nations International Strategy for Disaster Reduction) in year 2000, there has been more focus on regional level collaboration and networking, while still keeping the global agenda in mind. The key change from IDNDR to ISDR was the development of a comprehensive disaster risk reduction framework that focused on "risk reduction" issues, identified priorities on risk assessment, governance, investment, and so on, and provided for periodic measurement of progress toward goals. The Hyogo Framework for Action 2005–2015 had five key priorities. A quick look at the priorities of HFA document (UNISDR 2005) revels a strong role for science and technology in Priority 2 (Identify, assess, and monitor disaster risks and enhance early warning), as mentioned below:

> Support the improvement of scientific and technical methods and capacities for risk assessment, monitoring and early warning, through research, partnerships, training and technical capacity-building. Promote the application of in situ and space-based earth observations, space technologies, remote sensing, geographic information systems, hazard modeling and prediction, weather and climate modeling and

forecasting, communication tools and studies of the costs and benefits of risk assessment and early warning (UNISDR 2005, p. 8).

During the HFA implementation period, science and technology sectors have experienced increasing demands for disaster risk reduction both at the global and regional levels. But its national prominence was missing, except in a few countries like China, Japan, Malaysia, and so on. Thus, the upcoming years need to focus on an effort to:

- bring science into national and local government decision making in the Asian countries; and
- encourage innovative research and education linked to field practices.

The International Disaster Risk Conference (IDRC) Davos meeting of 2014 analyzed and presented key issues on the current status of science and technology in disaster risk reduction (IDRC 2014). The conference emphasized the need for a shift to the "science of how" from a "science of what," so necessary skills and knowledge bases are properly utilized and meet the "last mile" challenge of risk reduction.

The 2015 Tokyo Conference on International Study for Disaster Risk Reduction and Resilience called on policy-makers to empower their national DRR platforms through greater engagement with science and technology. The "Tokyo Statement" outcome document specifies that governments need to empower national platforms so that they can practice evidence-based disaster risk reduction for sustainable development (Science Council of Japan et al. 2015).

A recent report of the Science and Technology Advisory Group (STAG) of UNISDR (STAG 2015, p. 8) mentioned that:

> While political leadership and community partnerships are required for the successful implementation of effective, science-informed initiatives, the research community has a responsibility to formulate applicable methodologies and tools that respond to real-word challenges.

STAG (2015, p. 9) proposed the following six areas as highlights of the post HFA framework:

(1) Assessment of the current state of data, scientific knowledge and technical availability on disaster risks and resilience (what is known, what is needed, what are the uncertainties, etc.);
(2) Synthesis of scientific evidence in a timely, accessible and policy-relevant manner;
(3) Scientific advice to decision-makers through close collaboration and dialogue to identify knowledge needs including at national and local levels, and review policy options based on scientific evidence; and
(4) Monitoring and review to ensure that new and up-to-date scientific information is used in data collection and monitoring progress towards disaster risk reduction and resilience building.[…]
(5) Communication and engagement among policy-makers, stakeholders in all sectors and in the science and technology domains themselves to ensure useful knowledge is identified and needs are met, and scientists are better equipped to provide evidence and advice;
(6) Capacity development to ensure that all countries can produce, have access to and effectively use scientific information.

Out of these, the first four areas need specific involvement of science and technology in thematic areas, whereas the last two are cross-cutting activities for the first four actions, which are also applicable to the Sendai Framework.

3 Sendai Framework for Disaster Risk Reduction and Science and Technology

The Sendai Framework for Disaster Risk Reduction 2015–2030 (UNISDR 2015) has seven specific goals:

(1) Reduce global disaster mortality;
(2) Reduce number of affected people;
(3) Reduce direct disaster economic loss;
(4) Reduce disaster damage to critical infrastructures;
(5) Increase number of countries with DRR strategies;
(6) Enhance international cooperation; and
(7) Increase access to multi hazard EWS, risk information and assessment.

To achieve these goals, there are four key targets:

(1) Understand disaster risk;
(2) Strengthen disaster risk governance;
(3) Invest in risk reduction; and
(4) Enhance disaster preparedness for collective response, and to "build back better" in recovery, rehabilitation, and reconstruction.

Figure 1 shows a schematic diagram of the relative roles of science and technology community engagements. The estimation of the role of science and technology in the Sendai Framework is a qualitative evaluation based on the mention of science and technology in the framework and the importance provided in the priority areas. A quick analysis shows that Priority 1 (UNISDR 2015) has a strong role for the science and technology community in two very broad areas:

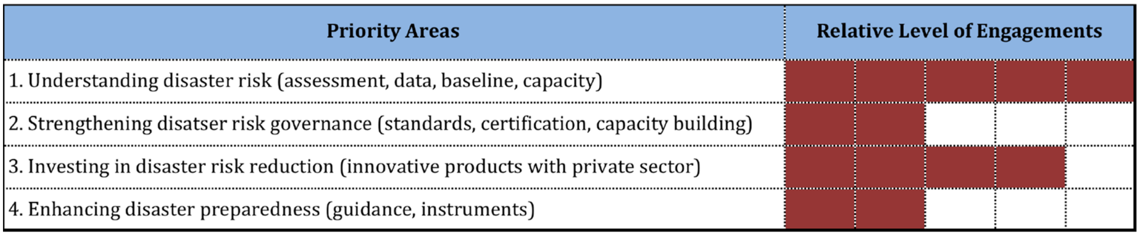

Fig. 1 Relative level of engagement of science and technology in the Sendai Framework priority areas

- National and local levels: data generation and management; baseline survey to measure progress; hazard, risk and vulnerability maps; GIS data bases; good practices, training and education; dialogue and cooperation of science and technology communities and policymakers, science-policy interface; strengthen technical and scientific capacity; promote investment in innovations and technology development; and incorporate disaster risk knowledge in formal and nonformal education.
- International and regional levels: development and dissemination of science- based methodologies and tools; science and technology partnerships with academia; enhancing science and technology work on DRR through existing networks and research institutions with support of ISDR and STAG.

In contrast, in Priority 2 area (UNISDR 2015), the roles of science and technology are limited to:

- Promotion of the development of quality standards, such as certification and awards for disaster risk management (DRM) with private sectors, civil societies, professional association and scientific organization, and UN (national and local levels); and
- Promotion of mutual learning and exchange of good practices and information through inter-alia, voluntary, self initiated peer review among interested states (international and regional levels).

For Priority 3, science and technology roles are:

- Promote disaster risk resilience in the work place through structural and non-structural measures, and encourage the revision of existing or new standards, codes, rehabilitation, or reconstruction practice (at national and local levels); and
- Promote academic, scientific, and research entities and networks and private sectors to develop new products and services to help reduce disaster risk (international and regional levels).

In case of Priority 4, science and technology roles are to:

- Develop guidance for preparedness and reconstruction (land use planning, structural standards improvements, and learning from recovery) (at national and local levels); and
- Promote further development and dissemination of instruments as standards, codes, operational guides, and other guiding instruments (international and regional levels).

The Science and Technology Community Major Group, in its statement in the World Conference on Disaster Risk Reduction (WCDRR) in Sendai, has emphasized the STAG (2015) recommendations of six actions, as mentioned earlier. In addition, it also mentioned that:

> We have learned from the Hyogo Framework for Action that in order to stop the increasing rate of loss of lives and livelihoods, we, the science and technology community, must break down the isolation of scientific knowledge. We need to actively assist governments and others in the uptake and use of this knowledge. This requires fostering deeper and wider partnerships across existing institutions and networks to scale up the application of science to decision-making at all levels (WCDRR 2015).

The science and technology community, as well as other stakeholders, came together at the United Nations Office for the Disaster Risk Reduction (UNISDR) Science and Technology Conference held 27–29 January 2016 in Geneva. The Science and Technology Roadmap to Support the Implementation of the Sendai Framework for Disaster Risk Reduction 2015–2030 and accompanying partnerships are the main outcomes of the conference. The six scientific functions identified by the Science and Technology Major Group were important in shaping the conference content and the Science and Technology Road Map (see Sect. 2 for the list).

The Science and Technology Roadmap to Support the Implementation of the Sendai Framework for Disaster Risk Reduction 2015–2030 includes expected outcomes, actions, and deliverables under each of the four priorities of actions of the Sendai Framework (UNISDR 2016). The science and technology community can then link to and plan around the implementation of the Roadmap. Work plans for several of the deliverables (with responsibilities, outputs, and a timeline) in the Roadmap can then be developed as appropriate. These can be developed on a needs basis, together with identified partners, with the support of the UNISDR Science and Technology Advisory Group. The partnerships that have been developed both for the Third UN World Conference on Disaster Risk Reduction in March 2015 and the UNISDR Science and Technology Conference in January 2016 are a core part of implementation of the Roadmap. The science and technology partnerships and initiatives help to complement and strengthen collaboration among the partners, within their respective mandates and expertise.

4 Pre- and Post Sendai Developments in Asia

At the regional level in Asia, the Science, Technology and Academia (STA) Stakeholder Group has been part of the ISDR Asia Partnership. The core area of interest and work of the group is to increase support for research and academia related to DRR (Bangkok declaration of AMCDRR, cited in Chatterjee et al. 2015), which need to be encouraged, supported, and implemented across all geographic levels. This should be done in an integrated fashion to support sustainable development, augment existing activities and mechanisms, as well as support new activities that adopt a trans-disciplinary approach.

At the sixth Asian Ministerial Conference on Disaster Risk Reduction (AMCDRR) in Bangkok, the voluntary commitment of the STA stakeholder group has identified following key objectives where STA can play important roles:

- *Research* Promote, prioritize, and advance research on natural, social, engineering, and technology aspects of disaster risk in an integrated environment; enhance team efforts in hazard and disaster monitoring and research, building on existing networks, universities, and initiatives; and integrate various stakeholder needs on all levels.
- *Higher education* Strongly promote multi-disciplinary disaster risk reduction in university education as well as professional training. This will ensure human resource development in the DRR field.
- *Integration* Ensure that disaster research programs, policies, and applications are integrated across disciplines, and contribute to enhancing policy-making and capacity building for effective DRR and sustainability.
- *Global standards* Develop and coordinate globally standardized open source information and data, event documentation and analysis procedures, guidelines, and frameworks for integrated and effective disaster risk management and sustainable development.
- *Awareness* Raise awareness of decision makers and the public by promoting effective, integrated, demand-driven, evidence-based disaster risk initiatives and increased advocacy.
- *Increase funding* Motivate funding sources (public, private, humanitarian, development, scientific, and so on) to allocate priority funding to address the urgent need for applied and basic integrated research on disaster risks. (AMCDRR 2014)

The statement by AMCDRR (2014) has also identified short, medium, and long term priorities on the number of universities that provide higher education in the region, attempted to increase research funding from within the region's countries and enhance the effectiveness of early warning systems in order to reach the mostneedy people. There is no major work that looks at science and technology application in Asia in a holistic way since the Sendai Framework was adopted. Chatterjee et al. (2015) provide possibly the only analysis that has focused on science and technology as well as private sector involvement in the region. They have pointed out that, from an Asian perspective, a holistic approach is needed to better integrate science and technology with DRR policies in the light of the high economic losses the region has suffered from disasters. Although the region has advanced significantly as observed in the Bangkok Declaration (Chatterjee et al. 2015), integration of science and technology in DRR is at present broadly based. The issues identified in the Sendai Framework stress the need for advanced and affordable early warning systems, greater involvement of the private sector in disaster research, and sharing nonstrategic data among the member countries; all of these concerns are in line with the Bangkok Declaration.

There has been increasing interest among the science, technology, and academia communities to be part of the national and/or regional process of disaster risk reduction, as evidenced from the gains made by HFA implementation. But there remain challenges to the integration of science into decision making or policy making at the national level, as well as to implementation at the local level. Therefore, an advisory group, the Asia Science Technology Academia Advisory Group (ASTAAG), was formed in May 2015, and was approved in the ISDR Asia Partnership meeting in Bangkok in June 2015. The advisory group has 10 members from eight countries. The key purpose of ASTAAG is to bridge the gap between regional discussion and national and local policy making, decision making, and implementation.

The basic principles in the involvement of science and technology in constructing policy and making decisions lie in innovations, customization, implementation, and transparency.

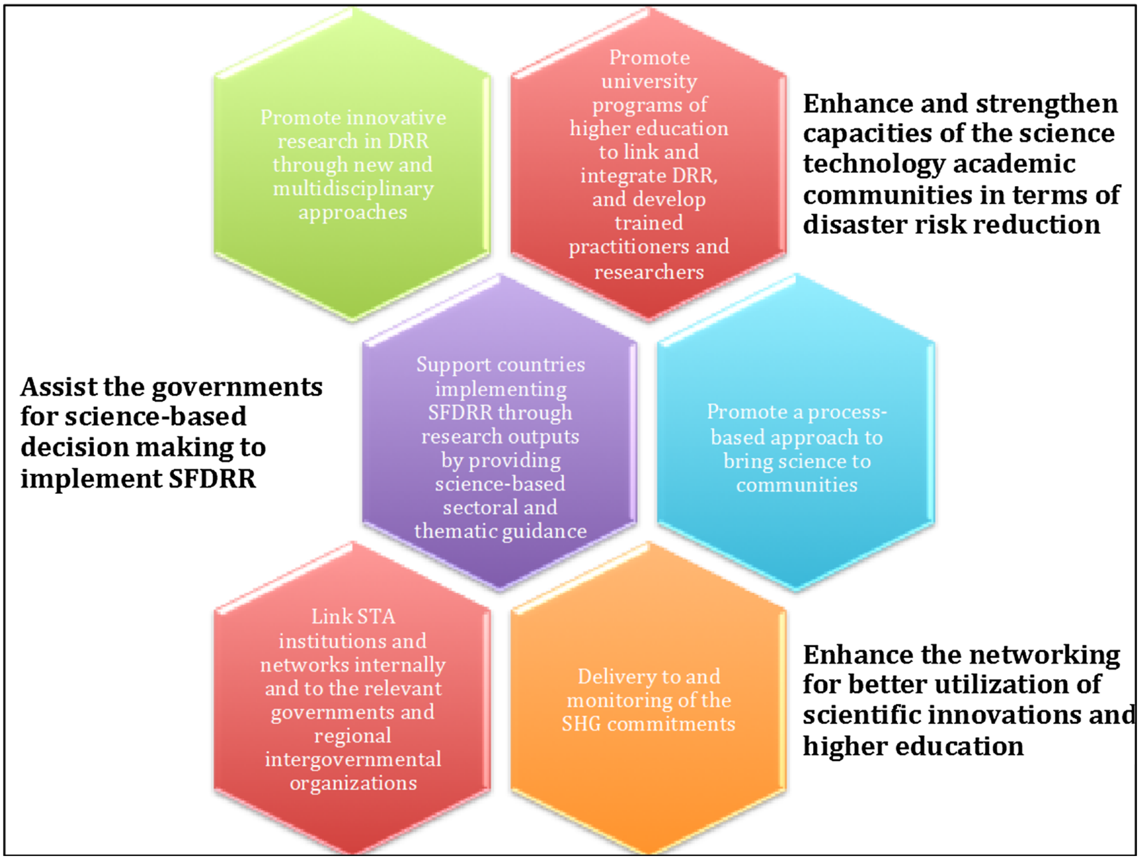

Fig. 2 Strategy of Science Technology Academia Advisory Group for Asia (STA: Science Technology Academia; SHG: Stakeholder group) *Source* ASTAAG (2015)

- Innovation is the key of science and technology, for developing new tools and methods of disaster risk reduction.
- Customization is another principle, which is required, keeping in mind the diversity of the Asia–Pacific region. The diverse social-economic-cultural and disaster risk context needs to be kept in mind while applying science and technology tools in different locations and customizing those tools for those locations.
- Implementation requires a clear focus of science and technology tools that link "the last mile" of knowledge to practice.
- Transparency is enhanced by a clear mandate for scientific and technical communities to stick to the code of conduct of scientific research, which insures that individuals and institutions will act with honesty, integrity, and transparency. (Kameda 2009)

The three key overlaying strategies of the advisory group are to:

(1) enhance and strengthen the capability of the science, technology, and academic communities in terms of disaster risk reduction;
(2) assist the region's governments achieve science-based decision making to implement the Sendai Framework; and
(3) enhance networking for better utilization of scientific innovations and higher education.

In doing so, the following sub-strategies were formulated (Fig. 2):

(1) Promote innovative research in DRR through new and multidisciplinary approaches: One of the key challenges lies in the capacity for innovation and research in different countries. The advisory group will try to promote and enhance the capacity for research and innovation on DRR in different Asian countries.
(2) Promote university programs of higher education to link and integrate DRR, and develop trained practitioners and researchers: To ensure proper education and training as well as quality control, universities and research institutions have strong roles to play to generate qualified professionals in DRR. This will be enhanced by providing better higher education and research facilities. Through the introduction of new certificate courses and customized higher education

courses, development of young professionals will be ensured. This upgraded and targeted training must be linked to the sustainability of disaster preparedness activities in countries and communities. The advisory group will promote synergy and linkages of DRR in higher education in different countries.

(3) Link STA institutions and networks internally and to the relevant governments and regional intergovernmental organizations: STA institutions need to be connected through networks to facilitate mutual exchange and sharing of research results and academic collaboration, which will strengthen the implementation of the Sendai Framework (SFDRR). This is required to share good practices, principles, and methods beyond national boundaries, and will serve the regional needs in the S-T role in DRR. Existing networks need to be strengthened in the region, and a synergy among different higher education and research networks is required.

(4) Support countries implementing the Sendai Framework (SFDRR) through research outputs by providing science-based sectoral and thematic guidance: The key component of the Sendai Framework is the integration of science and technology into national government decision making. This can be done by promoting scientific bodies, academic associations and institutions, and well-trained/individuals to the national disaster management offices. This is necessary to implement all four Sendai Framework priority areas (see Sect. 3). The level of intervention required will vary depending on the status of governance and the adoption level of risk reduction approaches. The advisory group is charged with encouraging the national STA institutions and networks to provide science-based advice to their respective countries.

(5) Promote a process-based approach to bring science to local communities: Similar to the national level, there is also a need to link science and policy into the local and community levels. This linkage of local government and local institutions needs to be strengthened under the basic framework of the national disaster risk reduction strategy. This will help to ensure the sustainability of the resource base at the local level.

(6) Delivery to and monitoring of the stakeholder group commitments: The advisory group will also work closely with the STA stakeholder group to ensure the delivery and monitoring of the commitments made in the AMCDRR.

In order to discuss the role of science and technology in the Sendai Framework, Kyoto University and the Association of Pacific Rim Universities (APRU)—a network of 45 leading research universities in the Pacific Rim region organized an annual symposium on 8 March 2016. This gathering brought together nearly 100 participants from academia/universities, governments, nongovernmental organizations (NGOs), and private sector representatives, among others, to discuss the anticipated challenges and key issues to be faced during implementation of the Sendai Framework. The structure of and discussion in the symposium were guided by the four priority areas of the Sendai Framework. While many recommendations were made for each priority, the participants strongly agreed to commit to:

(1) strengthen scientific community capacities through fostering young researchers and encouraging implementation of multidisciplinary and transdisciplinary research;
(2) continue support for the inclusion of science and technology innovations in national policy and decision making to achieve DRR;
(3) foster greater collaboration with local institutions and local governments to increase science- and technology-based decision making;
(4) learn from the experiences of good practices in the region and to foster further collaboration with various stakeholders; and
(5) contribute to organizing and supporting periodic science and technology conferences on DRR at national and regional levels.

5 Current Status of Science and Technology in Selected Asian Countries

To understand science and technology advancement in disaster risk reduction, the Asia Science Technology Academia Advisory Group (ASTAAG) has undertaken a survey in 11 Asian countries. The survey was conducted by the ASTAAG members as well as fellow scientists and researchers in close collaboration with policymakers and related stakeholders (Shaw et al. 2016).

It is important to clarify the methodology adopted for the survey. A literature review conducted by the ASTAAG members pointed out that there exist no clear indicators by which to determine the status of science and technology at a regional or country level. Aitsi-Selmi et al. (2016) have made some suggestions based on the Sendai Framework, for example, improve communication between scientists and decision makers, reform incentive systems, promote multidisciplinary and multi-sectoral approaches, and so on. They also suggests: (1) better data standards; (2) development of holistic risk models; (3) improved risk information and sharing; and (4) increased capacities across all sectors to achieve better evidence-based decision making. Beddington (2013) has emphasized the art of science advice, while Parker (2013) has argued that science advice would be more effective if there are more scientists and engineers in the government. Calkins (2015) conducted a survey in several different science academies to understand how countries want to use science, evidence, and technology in DRR. Six specific themes were used: (1) increased scientific research and practitioner engagement; (2) technology transfer and innovation; (3) open data access, knowledge management, and sharing; (4) communication and education; (5) stronger coordination and cooperation structure; and (6) cross-cutting capacity building. The study concludes that as an essential component to the development of countries, the entire science community has the opportunity to capitalize and compound benefits from existing disciplinary and interdisciplinary scientific organizations and technical tools to best serve a country's specific DRR priorities. As part of a movement towards a more integrated and comprehensive approach to DRR, improved science and technology allows quicker coordination, communication, and measurement of results.

Based on recent literature and other supporting documents, three specific areas of influence in science and technology were discussed and finalized among the ASTAAG members. These discussion foci were: (1) science and technology in decision making; (2) investment in science and technology; and (3) science and technology's link to people. These three categories are reflected in Table 1. Within each broad category, specific indicators were developed. For the attribute, decision making is a function of an available governance system employing a mix of tools and specific methodologies. Therefore, the first three indicators describe the disaster risk reduction system, especially the role of the science and technology community. The next five indicators describe how science is used in national level risk assessment, early warning systems, data collection capabilities, infrastructure design, and building codes and standards. The second attribute is investment in science and technology, in terms of financial and human resources, as well as science infrastructure and so on. The third attribute area is the most important one—the link between science and the general population. Several indicators were examined, including the availability to people of science-based risk assessment; participation of the science community in community consultation; and the validation of indigenous knowledge, among others.

For the country assessment, a scale of 1 (lowest) to 5 (highest) was used. The decision for each indicator was taken by a group of specialists in each country, in close cooperation with the disaster management office of the national government. This judgment was supported by specific evidence in terms of documents as well as discussion with relevant government departments. This evidence and discussion is listed in descriptive terms in Shaw et al. (2016). In the assessment, the relative importance and emphasis of science and technology in the Sendai Framework was also discussed, followed by short and long term actions required to enhance the progress of the three identified attributes. Finally, the status report ends with a note on higher education system in each country. The authors understand the dilemma of a qualitative judgment, but since the assessment was done by a diverse group of experts and practitioners through a consultative process, with proper evidence, the 1–5 value scale can be considered as an appropriate representation of the current status in the 11 countries involved.

Table 1 shows the relative score against different indicators, with the score of 1–5 indicated. A normalized score out of 100 is also presented at the bottom of the table. Some interesting observations can be made from this table. The purpose of this analysis is not to compare the countries; nonetheless, the overall score appears to show that China tops the 11 participating countries, followed by Japan and Indonesia. When the subattributes are considered, China is substantially ahead of other countries in terms of both incorporating science and technology into decision making and in investment in science and technology. But the science link to people part is weak and needs more attention. In contrast, although Indonesia is not that high in score for science-based decision making, its investment in science and technology is quite high. The most significant part is the science link to people, where Indonesia ranks tops among all 11 countries, along with Japan. Japan's score is a balanced one, with a relatively good performance in all three subattributes. Yet certain levels of improvement are required in order to strengthen the science link to people. Thus, the analysis is helpful to develop a country-based strategy to strengthen different aspects of science and technology with implications for increased disaster risk reduction.

In a comparison of the initial three categories, category 1: "Science and technology in decision making" has the highest score—an average 63 of the total scores of each indicator under the category. This indicates that decision making based on science and technology is well-managed compared to category 2: "Investment in science and technology" and category 3: "Link of science and technology to people". The science community needs to make further efforts especially to strengthen the link of science and technology to people as it often appears that the messages and results from academic and scientific researchers are difficult to understand and these data require translation into user-friendly terms.

In a similar comparison of each indicator, the highest normalized score (average 78) is received by indicator 1.5: "Existence of early warning system and mechanism with science and technology knowledge and tools". The lowest normalized score (average 27) is indicator 3.2: "Scientific

Table 1 Attributes of science and technology to DRR in 11 Asian countries *Source* Based on original data from Shaw et al. (2016)

	Attributes of Science and Technology to DRR	Bangladesh	China	India	Indonesia	Iran	Japan	Malaysia	Myanmar	Pakistan	Philippines	Vietnam	Average normalized score (out of 100)
1	*Science and technology in decision making (normalized score out of 100)*	45	90	70	68	63	85	70	48	50	53	53	63
1.1	Presence of science and technology advisory group to disaster risk reduction (DRR) nodal ministry and/or related ministries	2	5	4	3	2	4	4	2	2	3	2	60
1.2	Presence of science and technology group in DRR national platform	2	5	3	4	3	4	4	2	3	3	1	62
1.3	Existence of inter-ministerial discussion/dialogue on science related issues	1	4	2	3	2	3	4	3	2	2	2	51
1.4	Implementation of risk, needs, and damage assessment with involvement of science and technology group	2	4	4	3	3	5	2	1	2	3	2	56
1.5	Existence of early warning system and mechanism with science and technology knowledge and tools	3	5	5	4	4	4	4	4	3	4	3	78
1.6	Availability of disaster data/statistics on damage and impacts and its data collection mechanism	3	4	3	3	2	4	2	2	3	2	4	58
1.7	Involvement of science and technology group in infrastructure design	3	5	3	3	4	5	4	3	2	1	3	65
1.8	Scientific revision/updating of regulations, policies, and guideline for DRR including building code, disaster response, and preparedness plan etc.	2	4	4	4	5	5	4	2	3	3	4	73
2	*Investment in Science and Technology (normalized score out of 100)*	33	87	53	77	60	73	70	40	47	40	60	58
2.1	Existence of grant support by the national government to researchers in disaster related topics that focus on science and technology	1	5	3	5	2	4	4	1	3	3	3	62
2.2	Establishment of disaster related courses in higher education	3	5	3	4	5	3	4	2	2	2	2	64
2.3	Presence of national research institute and organization for disasters	3	5	3	4	4	4	3	2	2	1	4	64
2.4	Investment/support by the national government in national/international conferences and events on disasters for knowledge sharing	1	5	3	3	3	4	4	3	2	3	4	64
2.5	Support to collaboration with academia and the private sector for developing innovative technical solutions	1	3	2	3	2	4	3	1	2	1	2	44
2.6	Support to collaboration with academia and civil society for developing innovative social solutions	1	3	2	4	2	3	3	3	3	2	3	53

Table 1 continued

	Attributes of Science and Technology to DRR	Bangladesh	China	India	Indonesia	Iran	Japan	Malaysia	Myanmar	Pakistan	Philippines	Vietnam	Average normalized score (out of 100)
3	*Link of Science and Technology to People (normalized score out of 100)*	34	57	57	69	51	69	51	40	40	43	37	50
3.1	Availability of a hazard map to people, developed based on scientific knowledge	1	3	3	2	1	4	2	1	2	3	2	44
3.2	Scientific validation of indigenous knowledge	1	2	1	2	1	2	1	1	1	1	2	27
3.3	Involvement of science and technology group in developing program for evacuation drills	2	3	2	4	4	4	2	2	2	3	1	53
3.4	Availability and participation of science and technology group in community discussion as facilitator or advisor/commentator	2	1	3	4	3	3	3	2	2	2	3	51
3.5	Dissemination of science-based early warning and forecast to people	3	3	5	5	3	4	3	3	3	3	2	67
3.6	Involvement of science and technology group in developing disaster related education curriculum	2	4	4	4	4	3	4	2	2	2	1	58
3.7	Existence of facilities such as museum and events such as expo to disseminate disaster knowledge and deepen understanding on disasters among citizens	1	4	2	3	2	4	3	3	2	1	2	49
Normalized Science and Technology Attribution Score (out of 100)		38	78	60	71	58	76	64	43	46	45	50	57

validation of indigenous knowledge". This low figure implies that most of the 11 countries have not done the validation of indigenous knowledge that is needed and that there is nearly universal room for further improvement. In some cases, science and cultural/religious beliefs are contradictory and it is also a crucial role of science and technology to help understand this difference and its meaning for DRR.

The other section of the science and technology status report (Shaw et al. 2016) contains case examples of the application of science and technology to disaster risk reduction in Asia. In total, 28 case studies from 13 countries covering different hazards (glacial lake outburst flood, earthquake, drought, flood, landslide, salinity, tsunami, dzud, and typhoon), as well as some case studies in cross-cutting issues like cross-boundary flood, digital radio, resilient housing, school and river basin ecosystem. Many sectors are covered by disaster risk reduction practices, ranging from early warning systems, building safety codes, and climate change adaptation strategies to health impacts, educational innovations, agricultural losses, water contamination, communication disruption, and so on. The cases were submitted by academics, researchers, governments, intergovernmental bodies, donor agencies, civil societies, private sector organizations, and media outlets. This shows that to promote science and technology in DRR, scientists and academicians need to work closely with other stakeholders, and the ownership of the products and processes that are developed should be shared widely in order to achieve more inclusive, science-based decision making.

6 Future Emphasis and Way Forward

As a process to bring forward the collective momentum of science and technology in DRR in Asia, the first Asian Science and Technology Conference for Disaster Risk Reduction (ASTCDRR) was organized by UNISDR and its partners on 23–24 August 2016. The conference was attended by more than 300 professionals from more than 23 countries, and its goal was to discuss the key issues, challenges, needs, and opportunities existing in the application of science to policy making. The meeting also explored the way forward for the promotion of a functional science-policy interface for evidence-based policy making in DRR. The conference served as a regional multiple stakeholder platform from which to discuss the role of science and technology in DRR, as well as to provide specific inputs to the ministerial process of DRR in the region. Based on the discussion at the conference, and the need for a proactive role for science and technology in the region, a suite of 15 recommendations emerged that would, if widely adopted, enhance the role and application of science and technology in DRR in Asia. These recommendations are based on a survey of DRR status and practice in member countries under three major areas of influence (see Table 1). The first nine recommendations foster the science and technology group's capacities, both at the regional, national and local levels. The next four recommendations reinforce the Sendai Framework priorities, while the last two stress support for higher education and regional mechanisms by which to make further progress.

(1) Although the science, technology, and academia communities exhibited significant progress in science and technology capabilities in DRR during the implementation of the HFA, this community has also made its continued commitments assist in the implementation of the Sendai Framework. The science community also recognizes and emphasizes the importance of both natural sciences and social sciences in reducing disaster risks in the region. The community should also collaborate in, cooperate with, advise, and support the implementation of Asia Regional Plan at the regional, national, and local levels and through provision of knowledge, information, guidance, and tools that promote DRR.
(2) It is necessary to strengthen capacities of the science, technology, and academia communities in disaster risk reduction both at the national and local levels in the Asian countries.
(3) Enhanced networking both at the regional and national levels is required for better utilization of scientific innovations and higher education.
(4) At the regional level, the Asia Science Technology Academia Advisory Group (ASTAAG) should play a key role by providing overall advice and insight that will strengthen science and technology capacities in the countries.
(5) At the national level, the science-policy-practice nexus is important. To enhance the synergy of this connection, the science and technology community needs to take part proactively in national DRR platforms. National level multiple stakeholder and multidisciplinary science and technology plans need to be developed. These programs should support the implementation of the Sendai Framework in their respective countries.
(6) At the local level, a stronger collaboration of local governments (especially in the urban areas) and local resource institutes is envisaged and recommended. It is essential to recognize the good practices that exist at the local level on science-based decision making for DRR.

(7) It is also important to recommend that the science and technology communities should develop multi-stakeholder partnerships along with the private sector, civil society, and media, and deliver science-based solutions and provide implementation-based technology complete with user friendly tools and methods.

(8) Periodic assessment of the progress of science and technology in DRR in different countries should take place in terms of: (1) extending science and technology contribution to decision making; (2) increasing investment in science and technology; and (3) enhancing science and technology's link to people. These goals can be accomplished by close cooperation by national platforms through multiple stakeholder consultations.

(9) Successful applications of science and technology are available that mitigate risks from different types of hazards including flood, earthquake, drought, and other climate-related hazards. The widest possible dissemination of these tools and solutions is recommended to poor and vulnerable nations.

(10) In Sendai Framework Priority 1, the enhancement of national risk assessment and disaster loss accounting is strongly encouraged through appropriate and robust, widely acceptable methodologies and tools. Building the capability of both the scientific community for research and innovation, and DRR practitioners on the usability of innovative tools and methods is essential. The need to improve data standards and develop holistic risk models are of utmost importance. Utilization of space technology and proper capacity building for its uses in understanding risks at the national level needs to be enhanced.

(11) In Sendai Framework Priority 2, an enhanced role for science in risk governance through dialogue and network creation between scientists and policymakers is needed. A well-informed decision is the key to governance. Science can enhance the effectiveness of evidence-based decision making. Land use planning needs to be an important part of the mix of DRR tools, which can enhance governance mechanisms both in urban and rural areas.

(12) In Sendai Framework Priority 3, investment issues are emphasized. Different stakeholders are encouraged to work jointly to enhance science and technology investment. Meaningful research and greater access to higher education can contribute to building increased resilience of communities and societies. Science and technology need to play an additional role in risk-sensitive investment. To achieve this goal, scientists and administrators need to work closely with different stakeholders. Public–private partnership is an area that can be enhanced through the increasingly proactive roles of science and technology communities.

(13) Sendai Framework Priority 4 presents evidence-based models for resilience building through recovery and resettlement processes. It is recommended to promote enhanced, pre-disaster, recovery planning supported by science and technology to improve effective implementation of recovery efforts after disasters.

(14) Effective implementation of science and technology can be improved through the development of young professionals in the multidisciplinary field of disaster risk reduction. A more effective higher education is highly recommended, and, for that to occur, the disaster risk reduction academic field needs a disciplinary evolution through enhanced networking between universities and a strengthened and upgraded university curriculum.

(15) It is suggested that regional science and technology conferences should be held periodically, before regional ministerial meetings, so that the science and technology voice has its inputs as commitments for the implementation of the regional plan. A periodic biannual conference would also need to monitor the progress of science and technology in DRR at both regional and national levels.

After the Sendai Framework was adopted, there has developed a strong momentum to analyze, understand, and promote the role of science and technology in decision making. Several authors have analyzed the global progress and opportunities of DRR with major science and technology input (Calkins 2015; Aitsi-Selmi et al. 2016; Dickinson et al. 2016). Calkins (2015) found that most of the surveyed countries promoted research and practitioner engagement; increased technology transfer mechanisms; advocated open data access; communicated usable evidence and user's needs; expanded education and training; and, lastly, promoted international cooperation. Progress in these areas has contributed to national capacity building. The study pointed out that understanding DRR priorities and challenges will help decision makers and scientists in developing an implementation plan that considers how science, technology, and innovation can be enabling factors for more effective DRR. Since the establishment of ASTCDRR, the importance of science and technology planning has been highlighted. As a follow-up activity, Integrated Research for Disaster Risk (IRDR), along with its partners, has started the process of developing a multistakeholder science and technology plan for the implementation of the Sendai Framework.

Aitsi-Selmi et al. (2016) have emphasized the importance of coherence of science and technology in cross-cutting global frameworks, particularly the Sendai Framework, Sustainable Development Goals (SDG), and the Paris Agreement on climate change (UN 2015a, b). An analysis of these three major frameworks suggests that the importance of DRR to sustainable development, and the important of sustainable development to DRR, is well recognized (Shaw et al. 2016). The SDG and the Sendai Framework documents provide a strong foundation for ensuring that initiatives on DRR and sustainable development pay sufficient attention to each other's objectives. The climate change issue is also well recognized both in SDG and the Sendai Framework. In contrast, the Paris Agreement did not give much attention to the issue of disaster risk and its reduction. There is indisputable evidence of the strong linkages between development, environment, and disasters (Schipper and Pelling 2006; Tran et al. 2009; Shaw and Tran 2012). These connections mean that sustainable development (SD) can reduce pressure on the environment and can result in fewer disasters and reduced subsequent impacts. In turn, a well-prepared disaster risk reduction (DRR) approach and environmental management can reduce the impacts of disasters on development and can make development gains sustainable. Science and technology can provide innovative solutions to link these three frameworks from initial decision making to its implementation.

In conclusion, the role of science and technology is recognized in the Sendai Framework, and there is strong momentum at the regional level to bring it forward. As evident from the discussion above, science and technology implementation in DRR cannot be done by scientists and academics alone. Implementation needs multistakeholder collaboration, partnership, and mutual ownership of the problem and solution. At the regional level, periodic multistakeholder science conferences and science and technology status assessment are important; at the national level, development of a science and technology plan is crucial, and its implementation needs to be done both at the national and local levels. It is essential to collectively inject a "science voice" into DRR, especially by implementing the Sendai Framework at regional, national, and local levels.

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